Evaluation of Pulverized Coal Firing for a Calciner Air Heater

A Report for

Solvay Minerals Company

by

Dr. Kevin A. Davis

Reaction Engineering International

and

Dr. N. Stanley Harding

N.S. Harding & Associates

OBJECTIVE

To provide Solvay Minerals Company with estimates of potential NO_x emissions from a pulverized coal-fired furnace system to be retrofitted into their calcining process.

BACKGROUND

Currently, Solvay Minerals Co. in Green River, Wyoming operates a gas-fired furnace for generating a hot gas stream that is used in their trona calcining process. There is no steam or electricity production associated with this retrofit system and the natural gas-fired furnace is refractory-lined for process efficiency. The hot gases are then used to remove the CO_2 from the trona ore (calcining). Any excess heat in the gas is used to preheat the combustion air used in the furnace.

Originally, a coal spreader-stoker firing system was used to generate the hot gas for the process. As economics changed, a gas-fired system was installed and the spreader-stoker was removed. In the current environment, the cost and availability of local coal make it more economical than gas, the decision to convert back to coal firing is being entertained.

Solvay Minerals prepared the request to the Wyoming State Environmental division to permit them to change from the gas-fired system to a coal spreader-stoker system enhanced with currently available NO_x controls. The State has requested that Solvay investigate the potential for using a pulverized coal system with advanced NO_x control in order to minimize NO_x emissions. Solvay, in turn, has requested that Reaction Engineering International (REI) in Salt Lake City provide support for this endeavor.

REI PROGRAM

REI was requested specifically to perform the following tasks:

- Review with Solvay personnel key process conditions and constraints at the Green River, WY site.

- Identify and summarize potential technologies for pulverized coal firing
- Develop a list of potential suppliers of pulverized coal-fired furnaces and burners in the size range compatible with the Solvay process.
- Prepare a Request for Information for the potential suppliers and solicit responses.
- Identify and summarize relevant vendors
- Preparation of a quotation summary and critical evaluation

The first five tasks have been completed and this report provides the results.

DISCUSSION AND RESULTS

Reaction Engineering International (REI) personnel have held several discussions with Solvay Minerals personnel to obtain a thorough understanding of the calcining process in order to solicit information from potential suppliers of pulverized coal-fired furnaces and burners. Based on these discussions, the following list of operating conditions and process constraints was prepared:

- The total furnace heat input needs to be 200 MMBtu/hr.
- The coal to be used is a local Wyoming subbituminous coal.
- Due to existing process equipment, the maximum footprint and height dimensions for the retrofit furnace are:
    - Above ground – 40 ft (wide) x 33 ft (deep) x 62 ft (high)
    - Directly below ground – 40 ft (wide) x 58 ft (deep) x 22 ft (high)
- Existing equipment does not include a pulverizer, water or steam handling system or turbine and generator.
- Due to utilization of the hot flue gas in the process, the maximum air preheat temperature currently available is 225^{o}F.
- Limited space is available at the plant site for locating new equipment.

The focus of the entire inquiry was to obtain an idea of the potential NO_x emission from a pulverized coal system. This would be compared with the current emission level and the emission level estimated from a stoker-fired boiler.

With this information, REI prepared the request for information as shown in Figure 1 on the following page. This information provides enough detail so that the potential furnace and/or burner suppliers could determine if they would be interested in providing the necessary equipment for the retrofit. In addition, the desire was to receive an indication of the predicted NO_x emission from their system.

Figure 1.

REQUEST FOR INFORMATION: PULVERIZED COAL-FIRED FURNACE

Reaction Engineering International, an Engineering firm headquartered in Salt Lake City, UT specializing in computational fluid dynamic (CFD) modeling, is seeking information from potential suppliers of small industrial-scale furnaces which could produce a hot flue gas (1700°F - 1800°F) that would be used in a calcining process. Currently there is a gas-fired furnace (no waterwalls) that needs to be replaced for economic reasons. *Of primary importance is the anticipated NO_x emission from the pulverized coal-fired unit.*

The following is additional information that may be of help in determining the projected NO_x emission level:

- The total firing rate for the furnace is $200.x10^6$ Btu/hr; this can be done with one or two burners.
- Due to existing calciners and other process equipment, the maximum available footprint and height dimensions for locating the furnace are:
  - Above ground level: 40 ft (wide) x 33 ft (deep) x 62 ft (high)
  - Directly below ground: 40 ft (wide) x 58 ft (deep) x 22 ft (high)
- The coal available is a Wyoming subbituminous coal with the following analysis:

COAL ANALYSIS	As Received
Moisture, wt %	15.3
Ash, wt %	6.5
Carbon, wt %	60.6
Hydrogen, wt %	4.2
Nitrogen, wt %	1.4
Sulfur, wt%	0.5
Oxygen, wt %	11.5
HHV, Btu/lb	10,250

- Currently there is ***no*** pulverizer, ***no*** water or steam handling system and there is ***no*** turbine or generator on site. The current facility just produces hot flue gas.
- Combustion air is available but has a maximum temperature of 225°F due to process constraints.

Specific information requested:

- Can you supply a pulverized coal furnace in the 200 MMBtu/hr range?
- Given the constraints listed above, what would you guarantee as a NO_x emission level?

There are four major utility boiler manufacturers in the United States; they are Alstom, Babcock & Wilcox, Foster Wheeler, and Babcock Power Inc. (Riley Stoker). Three of these were contacted (Babcock & Wilcox, Foster Wheeler and Babcock Power) and the fourth, Alstom, has only limited experience with a wall-fired furnace and burner; therefore they were not contacted. In addition to the major boiler/burner manufacturers, Johnston Boiler an industrial boiler/burner manufacturer was contacted. The final contact was Black & Veatch, a reputable Architecture and Engineering (A&E) firm that specializes in boilers and furnaces. They have access to and have worked with many of the smaller furnace/burner manufacturers throughout the world. The following paragraphs summarize the responses from each contact. The entire written responses from each contact are contained in Appendix A.

Foster Wheeler

Mr. Stefan Laux, Manager of Combustion Systems at Foster Wheeler, was contacted. After a couple of discussions with Stefan, he called and said that he would estimate a NO_x emission of about 1.5 lbs/MMBtu due to the necessary refractory walls in the furnace. He felt that this would not be of interest to Solvay since the emissions are so high. Mr. Laux did not provide a written response, only verbal.

Babcock & Wilcox

Mr. Ron Lenzer was contacted at Babcock & Wilcox. In brief, his response was that "a technical response to your request requires a level of engineering effort which we would not invest unless there were a strong chance of B&W ultimately winning a sale." If Solvay were interested in proceeding with B&W, they should contact the nearest B&W Sales Office.

Babcock Power Inc.

Mr. Kevin Davis provided the response from Babcock Power. In essence, their response was similar to B&W's. They estimate it would take 18-20 weeks and cost between $55,000 and $60,000 to complete the necessary study to design the furnace and estimate the NO_x emissions. Again, if Solvay was interested in pursuing this with Babcock Power, they should contact either the Sales Office in Salt Lake City, UT or the Western Regional Office in Phoenix, AZ.

Johnston Boiler

Mr. David Thornock replied that Johnston Boiler is currently not offering pulverized coal-fired boilers or pulverized coal-fired combustion retrofit systems.

Black & Veatch

Mssrs. Mike King and Mark Dittus were contacted and provided with the system information. They thought that it was possible to provide the retrofit, but verbally they estimated the uncontrolled NO_x would be about 1.2 – 1.5 lbs/MMBtu. They contacted some of their clients who fabricate furnaces and burners. Two initial responses were received. The first, from General Electric – Energy & Environmental Research (GE-EER) mentioned that they felt they were well suited to provide the system, but needed to know the amount of money available, the payback time required and if the ash and unburned carbon would affect the process. No further information has been received from this potential supplier.

The second company, Damper Design, Inc., mentioned they looked at this or a similar process over 10 years ago with "favorable" conclusions. In fact, they have done NO_x emissions testing at the 80-100 MMBtu/hr range in a refractory-lined test furnace. Damper Design would fire about 5% of the currently used natural gas in a 10 MMBtu/hr duct burner that would be needed to assure drying of the coal by heating the primary air up to 375^{o}F. In addition, they recommend micronized coal (70% less than 400 mesh [37μ]) rather than just pulverized coal (70% less than 200 mesh [74μ]) to avoid flame impingement and improve particle burnout. Two companies, Williams and Fuller, offer pulverizers that will meet the micronized coal requirement. They also mentioned that the coal is not the best for NO_x control; that perhaps a PRB coal from northern Wyoming could be delivered at about $0.80-$1.00/MMBtu and result in even lower NO_x emissions. This cost is based on a project they did in Colorado where the PRB coal was delivered at $1.20/MMBtu. With the stipulations of micronized coal and an in duct heater using ~5% gas, Damper Design would guarantee a NO_x emission of 0.35 lbs/MMBtu and, if the moisture in the coal was over 25%, they would guarantee 0.30 lbs/MMBtu. Further, if a PRB coal was used, they felt they could get NO_x emissions levels down in the 0.25 lbs/MMBtu range.

CONCLUSIONS

Based on the information received, one prospective supplier, Damper Design, felt confident they could guarantee 0.35 lbs NO_x/MMBtu if they used 5% gas in an in duct heater and micronized coal. Others chose not to respond due to the costs required to complete an accurate estimation of the emissions. Verbal estimates of the NO_x emissions were about 1.2 to 1.5 lbs/MMBtu due to the hot refractory walls.

APPENDIX A

WRITTEN RESPONSES FROM POTENTIAL SUPPLIERS

BABCOCK & WILCOX RESPONSE

Stan Harding

From: "Lenzer, Ron" <rclenzer@babcock.com>
To: "Stan Harding" <nshjr@attglobal.net>
Cc: "Cioffi, Paul" <plcioffi@babcock.com>
Sent: Tuesday, January 28, 2003 7:10 AM
Attach: BurnerInfotoSuppliers.doc
Subject: Re: PC Industrial Furnace

Stan,

Unfortunately, a technical response to your request requires a level of engineering effort which we would not invest unless there were a strong chance of B&W ultimately winning a sale. If that is indeed the case, then your request should be sent to the nearest B&W Sales office.

Regards,

Ron

BABCOCK POWER INC.

Stan Harding

From: <kdavis@bbpwr.com>
To: "Stan Harding" <nshjr@attglobal.net>
Cc: <bfaia@bbpwr.com>; <kpatel@bbpwr.com>; <cpenterson@bbpwr.com>; <ktoupin@bbpwr.com>; <jpeck@mvpsic.com>; <tmartinko@bbpwr.com>
Sent: Thursday, February 06, 2003 10:51 AM
Subject: Pulverized Coal Fired Furnace - Inquiry No. 501234

Good Morning Mr. Harding:

Let me first apologize that a response to your request has not been very timely in being prepared and hopefully the delay hasn't resulted in any significant inconvenience.

The objective as understood is to replace the existing gas fired furnace with a pulverized coal fired furnace to support a calcining process. It was stated that consideration of fuel changes were being driven by economics.

If site conditions are presently undeveloped to handle coal, consideration will certainly need to be given to preparation aspects such as fuel handling. Specifically, unloading; stockpiling (duration); conveyance; pre-drying; bunkering; etc. These are issues which we would not become involved with and you would need to have addressed by others.

We could perform a technical evaluation to establish the fuel side coal delivery system from the bunker outlet to the combustor outlet. Specifically, feeder(s); pulverizer(s); coal pipe(s); burner(s); and combustion chamber. An air system to support the combustion process would also need to be evaluated. Specifically, this would include fan(s); motor(s); ductwork; duct heater(s); controls; etc. Electrical interface such as switchgears; cable trays; control room modifications; etc. would need to be addressed by someone other than our company.

Although you've provided an analysis of the proposed coal and proposed firing rate, without having a specific furnace design with which to calculate BAHR and account for the refractory lining, predicting NOx emissions is impossible at this time.

To review and establish basic system requirements as well as prepare a proposal drawing and cost estimate for the combustion system equipment from the bunker outlet to the combustor outlet, as well as to establish requirements and cost estimate of the supporting combustion air system, we would estimate the development cost of somewhere between $55K and $60K assuming availability and detail of plant drawings including location of the proposed coal bunker. Travel and living expenses associated with site visits or offsite meetings have not been included in the above estimate. Evaluation on system feasibility could also proceed on a time and material basis if deemed to be a more cost effective manner.

2/7/2003

BABCOCK POWER INC. (CON'T.)

This offering would be subject to reaching mutually agreeable terms and conditions prior to proceeding. The above estimate is also exclusive of any sales, use or other applicable tax. The duration of the proposed study is subject to workload demands which would need to be reviewed at time of sale. Presently we'd estimate 18 - 20 weeks to complete the study effort after notice to proceed

Thank you for your consideration of possible participation on the part of our company in this particular effort. If you have any questions regarding this offering, or would like additional information, please contact our sales agent in Utah who is Mr. John Peck of Mountain View Power & Industrial, Inc. located in Salt Lake City. John's phone number is (801)973-4455. Another contact would be Mr. Tom Martinko who is our Western Regional Sales Manager. Tom is located in Phoenix and can be reached at his office @ (623)875-6778.

Kevin G. Davis
Babcock Power Inc.
5 Neponset Street
Worcester, MA 01606
Tel: (508) 854-3818
Fax: (508) 853-3944

JOHNSTON BOILER

Stan Harding

From: "David Thornock" <davidthornock@johnstonburner.com>
To: "Stan Harding" <nshjr@attglobal.net>
Sent: Friday, January 31, 2003 7:43 AM
Subject: RE: PC Furnace

Stan.

Johnston Boiler Company is not currently offering PC fired boilers or PC fired combustion retrofit systems. Unfortunately we will be unable to assist you by supplying equipment on this job.

If there is any consulting work or review that needs to be done on this job, we are very willing to help out.

Regards,

David Thornock

BLACK & VEATCH
GENERAL ELECTRIC – ENERGY & ENVIRONMENTAL RESEARCH

Stan Harding

From: <todd.melick@ps.ge.com>
To: <DittusM@bv.com>
Sent: Tuesday, February 04, 2003 7:41 AM
Subject: RE: Solvay PC Furnace

I am still out from a double hernia operation. Just started reading email at home. Have not heard much from Eagleair for awhile. Yes we have seen some other coal for gas opportunities pop up. With our R&D background we would be well suited, this is not going to be off the shelf for anyone. How serious are they and how much money do they have? How many year payback would be attractive to them? Will the ash and UBC effect the process? Obviously we missed the February 1 target, what is the status now? These opportunities have a habit of disappearing when the gas price goes back down.

-----Original Message-----
From: Dittus, M. H. (Mark) [mailto:DittusM@bv.com]
Sent: Monday, February 03, 2003 3:53 PM
To: Melick, Todd (PS, EER)
Subject: FW: Solvay PC Furnace

Todd,

Following is an email and data on a project we have been approached about in Wyoming. The client is concerned with the unsure natural gas market and wants to see if it is feasible to convert their existing natural gas fired furnace to coal firing. The furnace is used strictly to produce hot gas for their calcining process, there is no steam or hot water produced at all.

The first questions we have are is this something Eagleair would be intersted in, what type of NOx emissions could you make and what type of performance guarantees would you be willing to provide.

I would appreciate any input you could provide on these questions, even a straight "we're not interested". If you have questions I let me know, I can try to answer them as best I can, unfortunately this project is so early in the stages I don't have a lot of information right now.

Regards,
Mark

BLACK & VEATCH
DAMPER DESIGN, INC.

Stan Harding

From: "Don Hagar" <damperd@gunnison.com>
To: "Dittus, Mark" <dittusm@bv.com>; "Peter Herrmann" <pherrmann@damperdesign.com>
Sent: Tuesday, February 04, 2003 7:03 AM
Subject: Calciner Burner for Solvay

Mark,

We looked at this over 10 years ago with favorable conclusions. I have lost the file, but the data is easily reconstructed. We felt we could replace 95% of the gas with coal.

Test firing we did several years ago in CE's refractory lined combustion chamber confirmed that the sole difference in NOx formation in such a furnace is peak flame temperature. This is controlled in our burner by the final venturi diameter. A 45% venturi is proven to achieve this. Water wall furnaces work very nicely with a 50% venturi.

Either one or two burners is feasible, but we would prefer two as being more certain of emissions results.

To avoid thermal NOx with the 45% venturi, the flame length would have to be close to 20 feet. A 26 to 30 foot deep chamber would avoid deposit problems. A 24 foot width with the burners 10 feet apart would avoid flame interaction and wall impingement.

Low combustion air temperature will cause high ash carbon, perhaps as high as 30%. Micronized coal would help reduce this, but we lack experience to offer a prediction on how much. The pulverizer will need a 10 mmBtu duct burner to assure drying of the coal by heating the primary air from 225 to 375° F.

The selected coal is not the best for NOx control. The best we could guarantee is 0.35 #/mmBtu. If the coal moisture were over 25%, we could guarantee 0.30 #/mmBtu. We would expect to demonstrate during testing levels 15% below these values (0.30 and 0.26).

Let me know if I need to answer any other questions.

Don

Mark,

I forgot to mention that exit temperature has to be controlled with dilution air. The burner gas temperature will be about 2,550° F.

We can't use high excess air to control temperature, it would raise NOx formation. I propose a maximum 13% excess air on the burners.

Don